

Dynamics," § 46). For several electrons there is no similar simple transformation. The "radiating" electron compels the remaining electrons to execute motions of reaction, which also influence the nucleus.

Probably it will be possible to derive a sufficiently approximate formula for the case of the *p*- and *d*-motions of lithium. This must be very difficult, however, for the case of the 1.5 S-path. The fact that at all events equation (1) cannot be true in general for atoms with several electrons will be shown by the following example (though of course on account of the Principle of Correspondence not representing a process really occurring in nature): two electrons move around the nucleus in a centrally symmetrical configuration, at first in a two-quantum and then in a one-quantum circle. By symmetry the nucleus remains continually at rest. In this case therefore the liberated energy and, consequently, the radiated ν would, contrary to (1), be exactly independent of the mass of the nucleus.

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I SHOULD like to add a few remarks to the interesting letter of Prof. Ehrenfest about the contents of which he was so kind to inform me before publication. As pointed out in his letter, the effect of the mass of the nucleus on the spectrum of an atom, containing more than one electron, is a complex problem which depends on the electronic arrangement in the states of the atom, involved in the emission of the lines, in a way which has hitherto not received sufficient attention. Not only may the mass effect disappear completely in such cases, where several electrons move round the nucleus in equivalent orbits, but, as indicated by Prof. Ehrenfest, this effect may also in case of the motions which we actually meet in the emission of the series spectra be different from that calculated for an atom with one electron.

Although in the emission of these spectra we are concerned with motions whereby a single electron moves in an orbit different in type from the orbits of the other electrons, the problem differs essentially from the problem of two bodies in celestial mechanics. Thus according to the picture of atomic constitution, outlined by the writer in two letters to NATURE (March 24, 1921, October 13, 1921), we shall assume that the electron connected with the emission of the series spectra, although during the larger part of the revolution it remains outside the configuration of the electrons in inner groups, it will nevertheless in certain states penetrate into the interior of the atom during its revolution. The fact that the electron in the inner loop of its orbit is subject to large forces is of preponderant influence as regards the fixation of the energy in the corresponding stationary states of the atom. For such a motion the effect of the nuclear mass might differ essentially from that estimated from an examination of the mechanical properties of the motion in the outer loop only, and the question arises, whether the mass effect is sufficiently large to account for the discrepancies, observed by Merton, in the wave-lengths of certain lines in the spectra of lead isotopes, which although very small are yet much larger than those to be expected from the simple formula quoted in Prof. Ehrenfest's letter.

Although this question seems difficult to settle without a closer investigation, it would scarcely appear probable that the answer will be affirmative. On the other hand, it cannot be excluded that the discrepancies in question are due to a slight difference in the field of force surrounding the nucleus, arising from the difference in the internal nuclear structure

of the lead isotopes. This possibility has been discussed from various sides. At first sight we meet with the difficulty, that the dimensions of the nucleus (ca. 3×10^{-12} cm.), estimated from experiments on the scattering of α -particles, are exceedingly small in comparison with the dimensions of the orbits of the electron responsible for the emission of the series spectra, which are of the order 10^{-8} cm. or larger.

This difficulty may disappear, however, by considering the circumstance mentioned above, that in certain states the series electron during a short interval of its revolution penetrates deeply into the interior of the atom. In fact, we must assume, that this electron in the states corresponding to the S-terms of the series spectra penetrates to even smaller distances from the nucleus than the electrons in the innermost group of the atom, the dimensions of which are in lead smaller than 10^{-10} cm. To the possible importance of this point in connection with the spectra of isotopes my attention was kindly directed by Dr. Kramers in a discussion about Prof. Ehrenfest's letter.

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The Destruction of Mosquito Larvæ in Salt or Brackish Water.

A NUMBER of experiments on the destruction of mosquito larvæ by the well-known system of "surface oiling," carried out at Hayling Island during the year 1921, supplied further evidence of the fact that this method is not one of universal application. The production of an unbroken film of a sufficiently lasting nature is sometimes an impossible task, notably in cases where the water surface is broken up by growths of reeds, etc., or is too freely exposed to the wind. In cases of this kind it is necessary to discard the oil film in favour of a "larvicide," that is to say, a substance which, by mixing with the infested water, will destroy the larvæ.

Unfortunately, however, practical information concerning larvicides is difficult to obtain. In the literature of the subject references are to be found to a number of suggested substances, but the vast majority of these stand self-condemned owing to the prohibitive cost that would be entailed by employing them in the prescribed "strengths" on any practical scale. A large number of these larvicides are, moreover, admittedly ineffective when added to brackish or salt water, and are consequently of little value in districts such as Hayling, where the salt-water mosquito, *Ochlerotatus detritus*, is the principal offender.

A number of tests have recently been carried out in the laboratory of the Hayling Mosquito Control, in the hope of discovering a larvicide which could be used successfully (and at a low cost) in salt, or partly salt, water. It was found that a liquid containing 15 per cent of soluble cresol, sold as a disinfectant under various names, gave very promising results in the laboratory. This liquid, at a dilution of 1 in 16,000, was found to kill the larvæ of *Ochlerotatus detritus* in one hour; at a dilution of 1 in 32,000, in one and a half hours; and at a dilution of 1 in 48,000, in three and a half hours. In the majority of these experiments the water containing the larvæ was of a salinity about half that of sea water.

In order to test this larvicide on a larger scale, a shallow stretch of brackish water adjoining the Hayling Golf Links was selected for experiment. This water was very heavily infested with the larvæ

of *Ochlerotatus detritus*, together with a large number of pupæ. Titration experiments carried out by Mr. Lyon Turner showed that the salinity of the water was 49 per cent. that of pure sea water.

After estimating the volume of the water as 20,000 gallons, it was decided to use the larvicide in the proportion of 1 in 16,000, the quantity required being therefore 1.25 gallons. The result of the experiment was entirely satisfactory, a thorough examination on the following day failing to detect a single live larva or pupa. Further examinations were made with the same result on April 26 and May 2, and on May 5 the success of the experiment was further confirmed by an examination made by Mr. P. G. Shute (Ministry of Health Laboratory).

Two other ponds badly infested with the larvæ of *Ochlerotatus detritus*, and containing a large number of pupæ, have since been treated with like success, a thorough examination of both ponds being made on the following day without a single live larva or pupa being found.

It was noticed during the experiments that the addition of the larvicide to one of the ponds in which the water was only slightly saline, produced the characteristic "miliness" associated with the use of disinfectants of this class. In treating the other ponds where the water was of greater salinity, this cloudy appearance was not produced, although the results obtained in all the three experiments were equally successful. A series of laboratory tests showed that the "miliness" occurred whenever the proportion of sea water to fresh water was less than 1 in 7, the cloudy appearance being uniformly distributed through the water treated. When the larvicide was added to water of greater salinity, it diffused in the form of minute globules. It was suggested by Mr. P. G. Shute that, in cases where the proportion of sea water exceeded one-seventh, the miliness (and the accompanying uniform diffusion of the larvicide) might possibly still be produced if the larvicide were diluted with a small quantity of fresh water before use. Experiment showed this to be the case, and this preliminary dilution is obviously to be recommended whenever the larvicide in question is to be added to water of appreciable salinity.

It is probable that successful results will be obtained with even smaller proportions of the larvicide than those employed up to the present, since the effects produced with dilution of 1 in 48,000 indicate that the limit has been by no means reached. Further experiments in this direction are now in progress.

It is important to note that water treated with this larvicide in the proportions mentioned is quite harmless to human beings or animals drinking it accidentally.

The comparative cost of "larviciding" and "paraffining" in any given case depends, of course, upon the depth of water to be treated. In cases where the water is shallow there is little to choose as regards expense, even when the larvicide is used in as large a proportion as 1 in 16,000. If d be the depth of any particular sheet of water in inches, n the "dilution" (or the number of parts of water which can be treated by one part of the larvicide), and c the ratio of the cost of the larvicide to that of paraffin, then the ratio of the expense of "larviciding" to that of "paraffining" has been shown by Marshall (*Science Progress*, January 1922, p. 468) to be given by the expression

$$(1500 \times c \times d)/n.$$

In the case of the first pond referred to above, d was 3 inches and n was 16,000. The price of the

fluid was 5s. 9d. a gallon, so that c may be taken as 4. Hence the relative cost of the operation, compared to paraffining, was

$$(1500 \times 4 \times 3)/16,000, \text{ or } 1.125,$$

the actual cost of treating the 1420 square yards of pond being about seven shillings. It should be noted, moreover, that as the water surface in this case was much exposed to wind, paraffining carried out on previous occasions had proved quite ineffective.

Since a cubic yard is the space occupied by 168 gallons, it will be found that the number of gallons in any piece of water is $(A \times d)14/3$, where A is the surface area in square yards and d is the depth in inches. So that, if the larvicide is to be used in the proportion of 1 in n , the number of gallons required will be $14/3(A \times d)/n$ gallons. This is a useful formula for calculation, particularly when a definite value of n has been decided upon for treating a number of ponds.

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The Teaching of Natural History in Schools.

In an article which appeared in *NATURE*, May 13, p. 628, dealing with the memorandum of a British Association Committee on this subject, the following statement occurred: "It devolves on the teachers of zoology to show in detail the kind of zoological syllabus that can be put into operation in schools as a basis for zoological teaching." May I be allowed, as one whose privilege it has been to teach zoology to some hundreds of boys, to offer one or two suggestions for such a syllabus?

The writer of the article was entirely favourable to the spirit of the memorandum, as indeed are a great number of persons responsible for the direction of education. With regard to the younger generation, the learners, the question is answered with no uncertain voice. I have put the choice of zoology or botany to forms of boys of all ages from 14 to 18, and have found invariably that 90 per cent. or more vote for the teaching of zoology. It may be that the boys scent my personal leaning towards zoology (though I try to be impartial) or, again, that they regard the study of animals as a more masculine pursuit than the study of plants. At the same time, it is evident that the boy's mind shows a genuine thirst for a knowledge of animal life.

There are two aspects of the application of zoology to the school curriculum. On one hand, there are the older boys who are being trained for some definite profession—medicine, agriculture, biological research, and so forth. On the other, there are large numbers of younger boys, very few of whom will ever require zoology as a professional subject, who are being taught biology as part of their general education. Zoological syllabuses for the professional examinations are issued by the various universities; moreover, in the Higher Certificate Examination zoology may be offered as a group subject. Thus, in the case of senior boys the biology master has ample guidance in the general requirements of a zoological education, and can develop and extend his teaching accordingly; but in teaching zoology to younger boys the master has to evolve his own syllabus and to form his own standard of attainment. It is with the latter aspect of the subject that I propose to deal.

The boy of fourteen when he comes to the study of biology requires something more substantial than